

What is claimed is:

1 (1. A sequential method for integrated, in-situ modification of a
2 substrate and subsequent atomic layer deposition of a thin film onto said
3 substrate in an evacuated chamber beginning with initial modification steps,
4 comprising:
5 introducing at least one first ion generating feed gas into said chamber;
6 generating a plasma from said ion generating feed gas to form ions;
7 exposing said substrate to said ions;
8 modulating said ions;
9 reacting said substrate with said modulated ions to remove any
10 contaminants from said substrate and producing a modified substrate; and
11 following said initial modification steps, performing an atomic layer
12 deposition of a thin film onto said modified substrate in said chamber including:
13 introducing a first reactant gas into said chamber;
14 adsorbing at least one monolayer of said first reactant gas onto said
15 modified substrate;
16 evacuating any excess said first reactant gas from said chamber;
17 introducing at least one additional ion generating feed gas into said
18 chamber, said additional ion generating feed gas ^{is} ~~may be~~ the same feed gas as
19 said first ion generating feed gas;
20 generating a second plasma from said additional ion generating feed gas
21 to form additional ions;
22 exposing said modified substrate to said additional ions;
23 modulating said additional ions; and
24 reacting said adsorbed monolayer of said first reactant gas with said
25 modulated additional ions to deposit said thin film.

1 2. The sequential method of claim 1 wherein said initial modification
2 steps are cleaning steps.

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1 3. The sequential method of claim 1 wherein said initial modification
2 steps are surface treatment steps.

1 4. The sequential method of claim 1 wherein said initial modification
2 steps additionally include introducing at least one radical generating feed gas
3 into said chamber and generating a plasma from said radical generating feed gas
4 to form radicals.

1 5. The sequential method of claim 1 wherein said atomic layer
2 deposition steps additionally include introducing at least one radical generating
3 feed gas into said chamber and generating a plasma from said radical generating
4 feed gas to form radicals.

1 6. The sequential method of claim 1 wherein said contaminants
2 comprise native oxides, metal oxides, particulate contamination, and carbon-
3 containing impurities.

1 7. The sequential method of claim 1, wherein said ion modulation is
2 modulated in a way selected from the group consisting of modulating an ion flux
3 and modulating an ion energy.

1 8. The sequential method of claim 1, further comprising electrically
2 biasing said substrate to a negative potential.

1 9. The sequential method of claim 8, wherein said electrical bias is
2 induced by a radio frequency power supply.

1 10. The sequential method of claim 8, wherein a magnitude of said
2 electrical bias during said initial cleaning steps is lower than a magnitude of said
3 electrical bias during said atomic layer deposition steps.

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1 11. The sequential method of claim 1 wherein said method is repeated
2 for each film deposition layer.

1 12. The sequential method of claim 1 wherein a barrier material film is
2 deposited following said initial modification steps.

1 13. The sequential method of claim 1 wherein a copper seed layer is
2 deposited following said initial modification steps.

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1 14. A sequential method for integrated, in-situ modification of a
2 substrate and subsequent atomic layer deposition of a thin film onto said
3 substrate in an evacuated chamber beginning with initial modification steps,
4 comprising:
5 introducing at least one first radical generating feed gas into said
6 chamber;
7 generating a plasma from said radical generating feed gas to form
8 radicals;
9 exposing said substrate to said radicals;
10 reacting said substrate with said radicals to remove any contaminants
11 from said substrate and producing a modified substrate; and
12 following said initial modification steps, performing an atomic layer
13 deposition of a thin film onto said modified substrate in said chamber including:
14 introducing a first reactant gas into said chamber;
15 adsorbing at least one monolayer of said first reactant gas onto said
16 modified substrate;
17 evacuating any excess said first reactant gas from said chamber
18 introducing at least one additional radical generating feed gas into said
19 chamber, said additional radical generating feed gas ^{is} may be the same feed gas as
20 said first radical generating feed gas;
21 generating a second plasma from said additional radical generating feed
22 gas to form additional radicals;
23 exposing said modified substrate to said additional radicals; and
24 reacting said adsorbed monolayer of said first reactant gas with said
25 additional radicals to deposit said thin film.

1 15. The sequential method of claim 14 wherein said initial modification
2 steps are cleaning steps.

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1 16. The sequential method of claim 14 wherein said initial modification
2 steps are surface treatment steps.

1 17. The sequential method of claim 14 wherein said atomic layer
2 deposition steps additionally include introducing at least one ion generating feed
3 gas into said chamber and generating a plasma from said ion generating feed gas
4 to form ions.

1 18. The sequential method of claim 14 wherein said contaminants
2 comprise native oxides, metal oxides, particulate contamination, and carbon-
3 containing impurities.

1 19. The sequential method of claim 14 wherein said method is repeated
2 for each film deposition layer.

1 20. The sequential method of claim 14 wherein a barrier material film
2 is deposited following said initial modification steps.

1 21. The sequential method of claim 14 wherein a copper seed layer is
2 deposited following said initial modification steps.

1 22. 'A single-module system for atomic layer deposition of a film onto a
2 substrate, comprising:
3 a main chamber containing a plasma generation chamber for generating a
4 plasma, said main chamber also containing an integrated cleaning and
5 deposition chamber for cleaning said substrate and depositing said film on said
6 substrate;
7 said plasma generation chamber coupled to receive at least one feed gas to
8 form said plasma; and
9 said integrated cleaning and deposition chamber coupled to receive at
10 least one precursor gas.

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